Annual Report – 2010
Quantifying, Predicting, and Exploiting (QPE) Uncertainty

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LONG TERM GOALS

The long term goal of our QPE work is to: 1) quantitatively understand what the uncertainties are in low frequency (10-1000 Hz) acoustic propagation and noise that are caused by variable and complex oceanography and seabed structure, 2) determine the limits to predicting the fluctuating and variable propagation and noise in this frequency regime and others, and 3) ascertain what naval advantage may be gained (if any) by understanding the nature of the uncertainty.

OBJECTIVES

Our primary objectives this year were to analyze the data from the main experiment in the East China Sea in 2009, and to work towards explanations of what was observed. Particular emphasis was placed on: 1) cataloguing the data set obtained for acoustics, 2) ambient noise data analysis, and 3) the theoretical explanation of the strong azimuthal anisotropy of transmission loss (TL) observed.

APPROACH

The main experiment to the northeast of northern Taiwan was successfully carried out in August-September, 2009. We have methodically looked through the environmental data, the OMAS signal transmission data, and the noise data to identify significant features. The noise data was examined, and bandpass filtered time series were created, as well as a catalogue of interesting events (and their possible origins). Regarding the azimuthal anisotropy of TL, a body of theory was generated which we feel could explain the strong anisotropy observed in this data set, as well as in the SW06 data set.

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WORK COMPLETED/ACCOMPLISHMENTS

Our accomplishments this year included: 1) a careful catalogue of the experimental data, as documented in a WHOI Technical Report, 2) a preliminary catalogue and analysis of the noise, which has been presented as an informal WHOI report, and which will be the basis for later papers, and 3) a body of theory explaining azimuthal anisotropy in TL, which will be part of papers on both this data set and a similar data set for the SW06 experiment.

RESULTS

During the QPE main experiment, we made 14 separate mooring deployments and recoveries, all of which gave us usable data, and in some cases extraordinarily good data. We had a maximum of four environmental monitoring moorings at each deployment site, and the temperature data from the sensors on one of these moorings is shown in Figure 1.

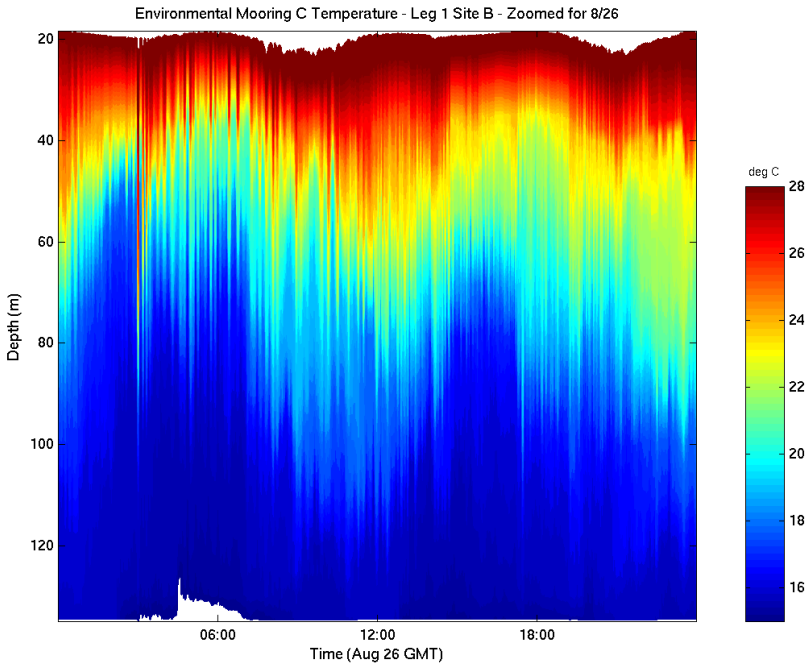

Figure 1. Section of thermistor string data from mooring at shelfbreak site B during leg 1 of the QPE main experiment. Very strong internal tides and internal waves are noted. One day of time is shown.

The very strong internal tides and internal waves are prominent, and should be large influences on acoustic propagation and noise at the experimental site.

Also deployed were two SHRU (several hydrophone receiver units) four-element vertical receiver arrays per deployment site, which gave a stationary moored counterpart to OASIS, Inc. drifting sonobuoys that were used in the area, as well as spatial diversity. These units were used to monitor

signals from the OASIS Mobile Acoustic Sources (OMAS), as well as monitor ambient noise in the area. We will discuss the latter in this report.

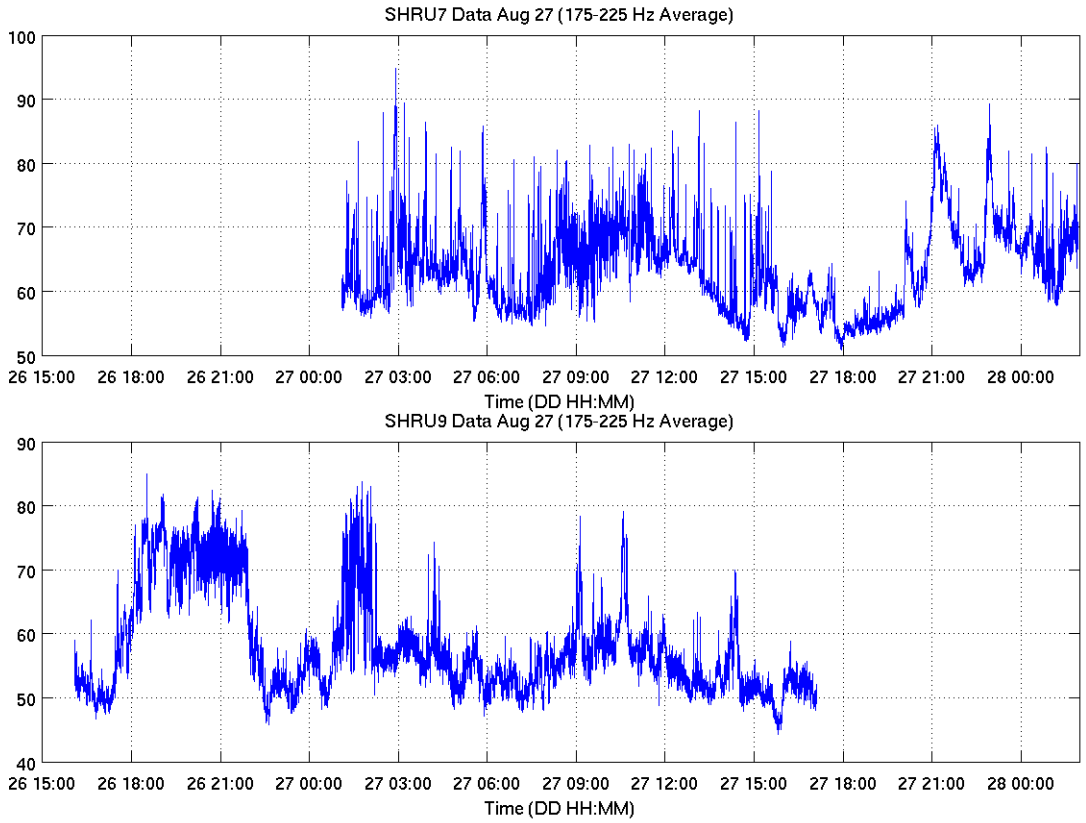

Figure 2. Ambient noise in the 175-225 Hz band, showing very large variation (up to 50 dB), a strong 12 hour period, and reasonable correlation between two receivers.

We see in the noise records from two of the SHRU units that the variability in the ambient noise is very high, and indeed is probably the largest source of uncertainty in the sonar equation. The causes of this variability and its predictability will be the subjects of our studies in the coming year.

IMPACT/APPLICATIONS

The impacts of our work so far are that we have seen interesting effects concerning: 1) azimuthal anisotropy, 2) ambient noise, and 3) propagation over slopes and canyons that may have naval sonar implications. We also see our data tying in to the larger Prediction, Quantification, and Exploitation of Uncertainty theme in the coming year.

TRANSITIONS

One eventual transition of our work will be to naval sonar systems and to sonar analysis, where the interest is in “the error bars” in ocean acoustic field and system performance prediction.

RELATED PROJECTS

The SW06 experiment also had an Uncertainty-related component, only in a different geographical area. OASIS Inc. QPE component. Numerous physical oceanographic QPE field studies. MIT data-driven modeling of the work area.

PUBLICATIONS

Newhall, A.E., J.F. Lynch, G.G. Gawarkiewicz, T.F. Duda, N.M. McPhee, F.B. Bahr, C.D. Marquette, Y.-T. Lin, S. Jan, J. Wang, C.-F. Chen, L.Y.S. Chiu, Y.J. Yang, R.C. Wei, C. Emerson, D. Morton, T. Abbot, P. Abbot, B. Calder, L. Mayer, P.F.J. Lermusiaux, "Acoustics and oceanographic observations collected during the QPE experiment by Research Vessels OR1, OR2, and OR3 in the East China Sea in the Summer of 2009", Woods Hole Oceanographic Institution Tech. Report, WHOI-2010-06, August, 2010.